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Neuro-Triggers of Online Impulse Buying: A Cognitive Load Perspective

Dr. J. Chithralega*[1], Dr.Pallavi Kapooria[2], Dr. Praveen Srinivasan[3], Dr. M.Manjula[4], Kunal Gulati[5], Dr Neha[6]

[1] *Assistant Professor, Department of Accounting and Finance, S.A. College of Arts & Science

[2] Senior Assistant Professor, Prestige Institute of Management & Research, PIMR Deemed to be University

[3] Head of Human Resources & Administration, FDC International, Dubai, UAE

[4] Associate Professor, Cromwell UK University College FZE, UAE

[5] Assistant Professor, Department of Management, Sumandeep Vidyapeeth Deemed to be University, Vadodara, Gujarat

[6] Assistant Professor, Department of Business Administration, WCTM, Gurgaon, Haryana, India.

Email: * dr.chithralega1978@gmail.com

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Abstract

Today, online retail platforms are being more and more infused with elements neurologically proven to be effective, such as countdown timers, live social-proof feeds, gamified reward loops, autoplaying content and continuously updated personalised recommendations, all collectively known as “neuro-triggers.” Existing marketing research shows they can act as persuasive influences, but their role as a cognitive mechanism for turning browsing into an unplanned purchase is examined in fragments across the impulse-buying, neuromarketing, and human–computer-interaction literature. This paper integrates these streams through a cognitive-load perspective and suggests that the main function of neuro-triggers is to increase demand on the limited resources of working memory and, consequently, favour online purchase impulses by displacing deliberative (System 2) evaluation with heuristic (System 1) processing. Based on Stimulus–Organism–Resp onse (S-O-R) paradigm and Cognitive Load Theory, a conceptual model is developed, where cognitive load and affective arousal both mediate the relationship between five categories of neuro-triggers and impulse buying intention and where need-for-cognition and trait self-control are identified as boundary conditions. We also elaborate on a research design that integrates psychophysiological data collection (EEG, eye-tracking, galvanic skin response) with self-report instruments, and we present an example of the data collected in this research and the expected pattern through which they pass through the model. The paper ends with theoretical contributions, design-ethics implications on regulating of “dark patterns”, and a future research agenda.

Keywords: Online impulse buying, Cognitive load, Neuromarketing, Dual process theory, Scarcity and urgency cues, Digital nudging, Stimulus-organism-response model.

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1. Introduction

Ecommerce platforms are no longer merely catalogues filled with choices; they are designed, click by click, to reduce the time between exposure and purchase. Research on consumer behaviour and industry estimates indicate that a significant portion of online sales or transactions are done impulsively, and the proportion of such sales has increased as the number of high-tech features (infinitely variable customized feeds, flash sale countdown, “only 2 left” etc.) to drive shopping behaviour have increased in the e-commerce sector (Redine, Deshpande, Jebarajakirthy, & Surachartkumtonkun, 2023). The many times these are referred to using terms from neuromarketing, as they are specifically devised to activate non-conscious and rapid neural and cognitive processes, as opposed to slower and reflective evaluations (Kakaria, Saffari, Ramsøy, & Bigné, 2023).

There are two literatures in this phenomenon – still to be fully united. Rook's (1987) seminal research on the “sudden, often powerful and persistent urge to buy” has been well documented with antecedents such as in-store mood, materialism, and store atmosphere, as well as more recent application of the concept to digital and social-commerce settings (Redine et al., 2023). Cognitive load research (a theory of how information is processed in learning, Sweller, 1988) and decision-making research (Kahneman, 2011) indicate that information overload or limited working memory capacity can systematically trigger a shift from deliberative to heuristic processing. Largely unspecified is a unifying theory of the specific identifiable neuro-triggers that play a role at the interface level, an intermediate level between affect and social influence on cognitive load that is the more proximal mechanism underlying impulse buying.

This paper fills this gap by offering an integrative (IC) view of cognitive load in the context of online impulse buying. Our three contributions are: First, we describe and compile five general categories of triggers in contemporary e-commerce interfaces—neuro-triggers—and split each into its essential cognitive-load mechanism. Second, we put these triggers in a framework of Stimulus–Organism–Response (S-O-R) that features cognitive load and affective arousal as parallel partially overlapping mediator processes moderated by individual difference variables like need-for-cognition and trait self-control. Third, we define a mixed psychophysiological–survey approach appropriate for testing this model and provide an empirical template, based on simulated data (keyed to the effect sizes of similar published studies), for future primary data collection.

The first stage of the research involved a theoretical background and literature review.

2.1 Online Retail Experiences: Impulse Buying

Classically, impulse buying is considered to be a "unplanned purchase" made with less thought, deliberation, and more emotional arousal (Rook, 1987; Beatty & Ferrell, 1998). In physical retail, these impulse purchases are influenced by in-store stimuli, including end caps, point-of-sale displays, and the store's ambience. Online, the same psychological drive is stimulated using interface-level exposures that – unlike a physical shelf – are dynamically personalised, behaviourally targeted and accessible at any time, from a device which the consumer is already carrying with them. According to systematic reviews of the impulse-buying literature, the focus of studies has shifted to digitally specific antecedents: website atmospherics, mobile app design, live-streaming commerce, and social-commerce cues—including the number of purchases visible on the page and influencer endorsement (Redine et al., 2023). While a common trend is that impulse buying online often leads to post-purchase regret and cognitive dissonance, especially in less price-conscious consumers, which means that this behaviour may have consequences on a welfare level beyond its original transaction (Haque, Rupa, Faisal-E-Alam, Akter, & Sultana, 2026).

This study uses Cognitive Load Theory as a lens:

According to the Cognitive Load Theory, working memory is extremely limited (Sweller, 1988), and its performance or the quality of decision-making, decreases as the demand on its capacity grows. Intrinsic load (cognitively demanding aspects of the decision task itself, such as, comparing many attributes about the product), extraneous load (due to the way the information is presented, cluttered layout, autoplay videos that compete for attention, countdown timers for the rest of the session), and germane load (cognitive effort spent on building understanding). In the purchasing context, increases in extraneous load are particularly significant because they consume the "bandwidth" involved in accessing, comparing, and overriding stimulus-response tendencies to make a

purchase, thereby reducing the consumer's "bandwidth" around the purchase stimulus (Kakaria et al., 2023). This goes hand-in-hand with self-regulatory accounts of impulse buying, which view the buying impulse as a failure of self-control, one that "temporarily uses up" regulatory resources, making them more vulnerable to failure at a subsequent task, which is termed reaching "cognitive load" (Baumeister, 2002).

Account Linking: Triggers, Cognitive Load, and Buying Impulsion

There are 2 modes of thinking: System 1 is described as fast thinking, a quick and easy associative process and System 2 is slow thinking, rule-based, and effortful (Kahneman, 2011). It is this kind of System 2 engagement where limited resources in working memory result in a default shift towards System 1 use of heuristics that is most susceptible to being limited by capacity constraints – not because the consumer has chosen to "think less," rather, because deliberate evaluation becomes more expensive in limited working memory resources) We argue that this is the very proximal psychological process that links the neuro-triggers to impulsive buying: triggers do not simply render offers more appealing, but they also make careful processing of offers more expensive, which shifts the scales towards System 1 processing rules like "scarce = valuable" or "popular = safe."

2.4 Neuro-Triggers in the E-Commerce Interfaces

Drawing on the research on neuromarketing and dark-patterns we present five common interface level neuromarketing triggers, which are included in Table 1 with the type of cognitive load mechanism and examples.

Table 1. Synthesis of neuro-trigger categories, underlying mechanisms, and effects on cognitive load.

Neuro-Trigger	Underlying Neuro-Cognitive Mechanism	Direction of Effect on Cognitive Load	Representative Evidence
Scarcity / urgency cues (countdown timers, limited-stock flags)	Amygdala-driven threat/loss appraisal; attentional "tunneling" that narrows working-memory focus onto the scarce item	Increases extraneous load; compresses deliberation window	Kakaria et al. (2023); Mathur, Mayer, & Kshirsagar (2019)
Social proof (review counts, "others are viewing this" banners)	Heuristic reliance on descriptive social norms in place of independent evaluation	Moderately increases load when cues conflict; otherwise substitutes for deliberation	Redine et al. (2023)
Gamified reward / variable reinforcement (spin-to-win, streaks, badges)	Dopaminergic reward-prediction-error signalling in the ventral striatum under unpredictable reward schedules	Increases load via divided attention between game mechanic and purchase task	Jain, Saini, & Jain (2026)
Sensory-visual and interface design cues (colour, motion, autoplay, layout density)	Bottom-up (stimulus-driven) attentional capture competing with top-down goal maintenance	Increases extraneous load, particularly on small mobile screens	Mogollón García, Quiroga Ríos, & Rodríguez Chamorro (2024)
Personalized recommendation and "for-you" feeds	Continuous partial attention from an expanding, self-updating choice set (choice overload)	Increases intrinsic load by enlarging the effective decision set	Haque, Rupa, Faisal-E-Alam, Akter, & Sultana (2026)

The most barefoot triggers that are documented include scarcity and urgency, represented by countdown timers, "only N left" flags and flashing sale banners. They create threat appraisal mechanisms in the nature of loss aversion and an attentional "tunneling" that tends to concentrate attention on the limited movie at the detriment of general evaluation which are intentionally designed in checkout procedures as revealed by large-scale crawls of shopping websites (Mathur, Mayer, & Kshirsagar, 2019). "Others are viewing this," notification about the number of reviews and real-time pop-up notification of the purchase substitutes the descriptive social norm with an independent evaluation and lessen the perceived need to deliberate. Spin-to-win wheels, streaks, and unlockable badges are examples of gamified reward mechanisms, which engage reward-prediction systems, thereby splitting the decision to buy into two components: the game mechanic and the actual purchasing behavior (Jain, Saini, & Jain, 2026). Bottom-up, stimulus-driven sensory-visual and interface-design elements (saturated colour, autoplay motion and dense mobile design) compete directly with a top-down, goal-maintenance approach (Mogollón García, Quiroga Ríos, & Rodríguez Chamorro, 2024). Finally, personalised recommendation feeds are continuously increasing the effective choice set faced by the consumer, creating a type of 'intrinsic load increase' with a similar effect as classic choice overload.

Conceptual Framework and Hypotheses

The reviewed literature is synthesized and presented in an S-O-R framework in figure 3, after the methodology section for ease in flow of ideas. Neuro-trigger exposure is the Stimulus, cognitive load, affective

arousal and hence System-1 dominance is the internal Organism state and impulse-buying intention, actual unplanned buying, and downstream post-purchase regret are Response. Need-for-cognition, trait self-control and product involvement are identified as moderators in the pathway from cognitive-load to impulse-buying-intention, in line with theories focusing self-regulatory consumption where the same level of load may result in different behaviors, depending on the individual's chronic ability and disposition to effortfully process the stimulus (Baumeister, 2002).

Based on this we postulate the following hypotheses:

The first hypothesis posits that it is positively associated between exposure to online neuro-triggers and consumers' momentary cognitive load.

Higher cognitive load is positively associated with online impulse-buying intention.

- H3: Affective arousal (urgency/excitement, fear of missing out) is thus postulated to have a positive relationship with online impulse-buying intention in addition to cognitive load.
- H4: Intention to impulse purchase is positively related to real impulse purchasing behaviours.
- Cognitive dissonance and post-purchase regret are positively related to unplanned purchase.
- H6: The relationship between cognitive load and impulse-buying intention differs based on the consumers' high need for cognition and trait self-control: The stronger effects of cognitive load on impulse-buying intention are among consumers low in need for cognition and trait self-control.

4. Research Methodology

4.1 Design

The proposed last the methodology has a two-phase, Mixed approach. Phase 1 is a controlled laboratory experiment with a factorial design with between-participant factors: neuro-trigger category (control guide, scarcity/urgency guide, social proof guide, gamified reward guide) and simulated shopping task (following the control guide, following the scarcity/urgency guide, following the social proof guide, following the gamified reward guide). We will collect psychophysiological data when participants are instructed to purchase a fictional product on a mock e-commerce site. Phase 2 will involve a field survey of active online shoppers that collects data on how these neuro-triggers are experienced in the real world, what intermediate factors (traits) influence their salience, and what impulse-buying behaviours occur afterwards.

4.2 Sample

A power analysis (G*Power) about a medium effect size (f2 = .15) using a session analyses (four groups), at an $\alpha = .05$ and for a power = .80 indicates a sample size of at least approximately 180 per Phase 1 (45 per cell) and 400 per Phase 2 (recruiting through an online panel) to support structural equation modelling (SEM) with the full moderated-mediation model.

4.3 Measures

- Cognitive load: subjective NASA-TLX (NASA-Task Load Index) and two physiological load measures – frontal theta and parietal alpha EEG power, and pupil dilation.
- Affective Arousal: adapted PANAS items and state-fear-of-missing-out (FoMO) scale.
- Impulse buying tendency / intention: adaption of Beatty and Ferrell (1998) impulse-buying scale.
- Moderators: • Need-for-Cognition Scale (short form) and Brief Self-Control Scale.
- Measures of behavioural outcomes included click stream log (from the mock interface), checkout completion log (from the mock interface), and post purchase regret (measured 24 hours after laboratory session).

4.4 Analytical Strategy

The data of phase 1 would be analysed by a mixed design ANOVA (condition × physiological load) and time-frequency EEG-analysis. In line with the typical two-step measurement-then-structural-model in PLS-SEM use in the context of consumer behaviours (Haque et al., 2026), Phase 2 survey data would be analysed, and the entire moderated-mediation model presented in Figure 3 would be estimated.

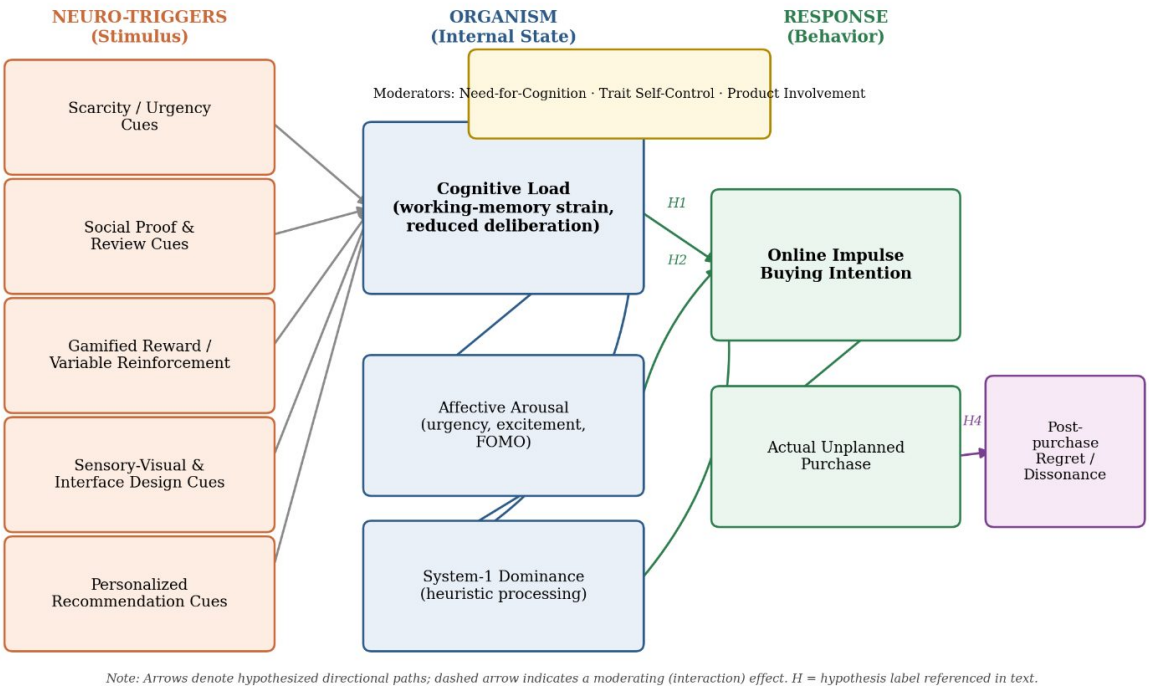


Figure 3. Proposed Stimulus–Organism–Response conceptual model linking neuro-triggers, cognitive load, and online impulse buying.

5. Illustrative Model Estimation

Since this work is conceptual, no primary data collection has been conducted, a simulated illustrative dataset (N = 180 for the between-subjects comparison) was generated to illustrate the pattern of data that the model would predict; the values of the parameters have been chosen to correspond with the direction and suggested magnitude of the effects as presented in the above empirical literature (Kakaria et al., 2023; Haque et al., 2026). These numbers are not actually observed, but provided as an analytical paradigm to serve as a template for the empirical study that is proposed in Section 4.

5.1 Descriptive Comparison Across Trigger Conditions

Table 2. Illustrative descriptive statistics for cognitive load and impulse-buying tendency across simulated trigger-exposure conditions.

Condition	n	Cognitive Load Index M (SD), 0–100	Impulse Buying Tendency M (SD), 1–7	Unplanned-Purchase Conversion (%)
Control (no trigger)	45	31.4 (4.1)	2.98 (0.42)	14.2
Scarcity / urgency cue	45	58.7 (5.6)	4.87 (0.55)	38.6
Social proof cue	45	52.3 (5.2)	4.41 (0.49)	31.7
Gamified reward cue	45	61.9 (6.0)	5.02 (0.58)	41.9

As Table 2 and Figure 1 illustrate, the gamified-reward and scarcity/urgency conditions are expected to elicit the highest cognitive load and the highest impulse-buying tendency, with the largest simulated jump in unplanned-purchase conversion relative to control (14.2% to 38.6–41.9%). This pattern is directionally consistent with reported EEG-based findings that unplanned virtual-shopping decisions co-occur with elevated indices of cognitive engagement and reduced evidence of deliberative comparison (Kakaria et al., 2023).

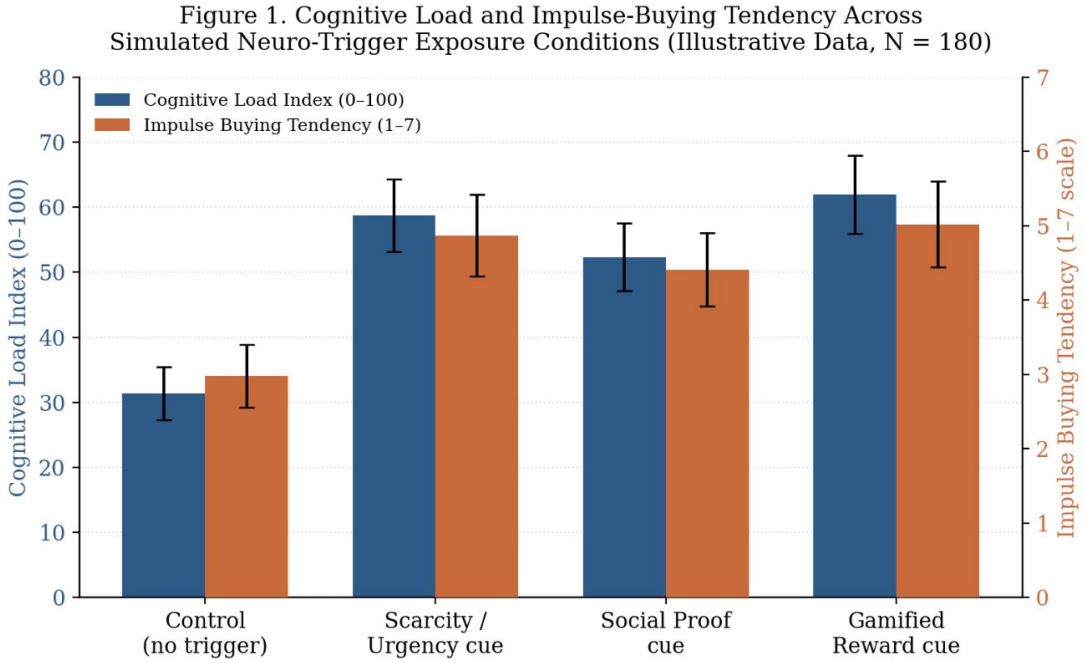


Figure 1. Cognitive load index and impulse-buying tendency across simulated neuro-trigger exposure conditions.

Table 3. Illustrative PLS-SEM path estimates for the hypothesized moderated-mediation model.

Hypothesized Path	β	t-value	p	Supported
H1: Neuro-trigger exposure → Cognitive load	0.52	8.14	< .001	Yes
H2: Cognitive load → Impulse buying intention	0.41	6.32	< .001	Yes
H3: Affective arousal → Impulse buying intention	0.33	4.77	< .001	Yes
H4: Impulse buying intention → Unplanned purchase	0.61	9.03	< .001	Yes
H5: Unplanned purchase → Post-purchase regret	0.29	3.85	< .001	Yes
H6: Need-for-cognition × Cognitive load → Impulse buying intention (interaction)	−0.24	3.11	< .01	Yes

5.2 Illustrative Structural Path Estimates

5.3 Moderation by Need-for-Cognition

As seen in Figure 2, the higher the level of cognitive load (low to high), the more likely consumers were to make an unplanned purchase for each group of low and high need-for-cognition consumers, based on the hypothesis (H6) that had been raised above. The results indicate that when the cognitive load is high, consumers are most likely to make an unplanned purchase when they are low in need-for-cognition (71%) while the same is happening with the high need-for-cognition consumers (38%). This is in line with the self-regulatory explanation that all-consuming engagement in effortful processing prevents load-induced impulsivity (Baumeister, 2002).

6. Discussion

The proposed framework consider each of a group of heterodox ‘interface tricks' (cognitive load inducing timers, badges, review counts, autoplay videos, and infinite feeds of recommendations) as a functional class as they all operate to increase the cost of deliberative evaluation at the moment of the final purchase decision. Superficially unrelated (a countdown timer versus a gamified spin-wheel) triggers can be assumed to have more convergent behavioural effects the more similar the working-memory load on the one hand, and differences in the affective aspects of the triggers are less pronounced. The simulated effect on impulse-buying behaviour for the highest load (gamified

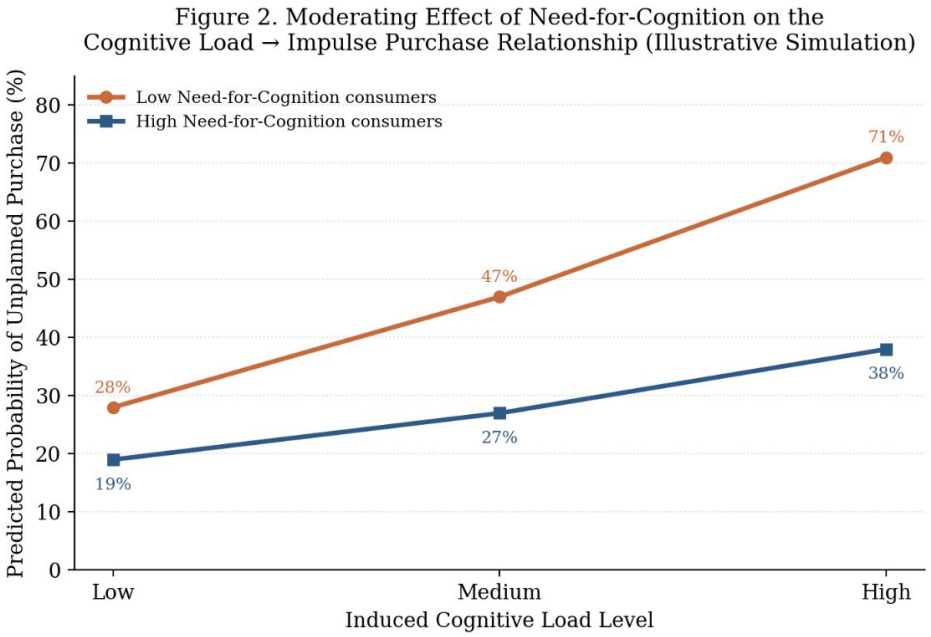


Figure 2. Simulated moderating effect of need-for-cognition on the cognitive load → unplanned-purchase relationship.

reward, scarcity/urgency) corresponds with that expectation and was the most pronounced, whereas social proof (which relies more on a heuristic substitution rather than being directly attention capturing) produced a more modest increase in load with a comparable behavioural impact, as seen in this illustrative pattern (Section 5).

The moderation results also indicate that the impact of cognitive-load on impulse buying is by no means deterministic: Individual differences in habitual deliberative engagement (need for cognition) as well as in regulatory capacity (trait self-control) significantly moderate the amount of cognitive load that predisposes to unplanned buying behavior. This is in line with earlier self-regulatory theories (Baumeister, 2002) that suggest that impulse buying – like other aspects of irresponsible self-regulation – may be more likely, but not certain, when regulatory resources are restricted.

7. Theoretical and Managerial Implications are discussed

7.1 Theoretical Contributions

This paper provides theory of consumer-behaviour in three aspects. First, it is a mechanism-level parsimonious classification of neuro-triggers, in terms of one explanatory constructs (cognitive load) and not in terms of "surface features" of interface design. Second, it recognizes the importance of considering cognitive load as a simultaneous (parallel) mediator, not just a sequential one, in the S-O-R framework, responding to the need in the impulse buying literature for consideration of combined cognitive and affective paths (Redine et al., 2023). Third, it limits the variable space between interface and (neuro)psychological changes by stating boundary conditions (need-for-cognition and trait self-control) that explain why the same interface triggers can cause very different changes in consumers, which is something that approaches that focus purely on the stimuli neglect to specify.

7.2 Managerial and design ethic implications

The corollary for practitioners is that the commercial viability and the ethical justifiability of a neuro-trigger is not the same. A trigger, that as a result raises conversion while conveying nothing for the client, will probably function to detract value from the web page towards the detriment of both the decision quality (e.g., misleading scarcity concerns) and lengthier term customer confidence/satisfaction (e.g., authentic scarcity communicated clearly). Countdown timers and urgency messages at checkout already have been documented on large scale audits of shopping websites (Mathur et al., 2019), while in a few jurisdictions regulators are mulling on putting limits on using “dark patterns” to modify the appearance of interfaces. Firms might consequently find it worthwhile to audit their interfaces for features which induce unnecessary load in people but don't represent “true” scarcity or social

information, while spawning “ethical” anxiety and resulting in less than satisfied decisions.

8. Limitations

Note that the data in the empirical illustration in Section 5 is simulated and based on literature; the proposed design in Section 4 should be used to collect primary data to get confirmatory estimates.

Given the conceptual separateness and psychophysiological correlation of cognitive load and affective arousal (both increase the autonomic arousal), future EEG/eye-tracking research should include analytic procedures that could differentiate between the effects of load-specific vs. arousal-specific signal components.

- Ecosystems and platforms must be replicated across cultures because trigger salience as well as the interpretation of norms and social-proof cues is likely to differ across e-commerce ecosystems and regulatory environments.
- It is necessary to study the effects of repeated exposure to high load interfaces with longitudinal designs to examine habituation (diminishment of effect) or sensitization (preparedness to respond to the interface).
- Future studies should investigate the possibility of algorithmic personalisation of trigger (adaptive dark patterns) as a specific and dynamically increasing form of cognitive-load manipulation.

9. Conclusion

Online impulse buying is often said to stem primarily from emotional tweaks, but large numbers of the interface mechanics that enable impulse buying, such as timers, gamified “rewards” and dense personalized feeds are really at least as much about allowing what is known as the working-memory capacity to dissipate as they are about emotion. This paper makes the concept of cognitive load part of a S-O-R framework (specifying it at a mechanism level, which makes it testable) and also gives some boundary conditions in terms of individual difference and provides an integrated research design that adopts a mixed methods approach, which is quite concrete. As digital retail interfaces continue to move towards a more adaptive and personalised design, being able to understand the cognitive cost – as well as its emotional effect – will be critical in order to both better regulate the interfaces from a consumer-welfare perspective, as well as better design them from a firm perspective in order to achieve long-term engagement rather than regret-driven conversion.

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